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Soil Moisture Active Passive Mission
SMAP

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Improving Brightness Temperature Measurements Near Costal Areas

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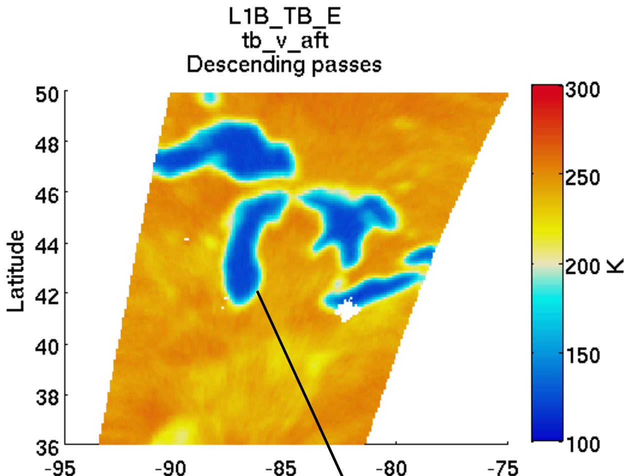
Outline

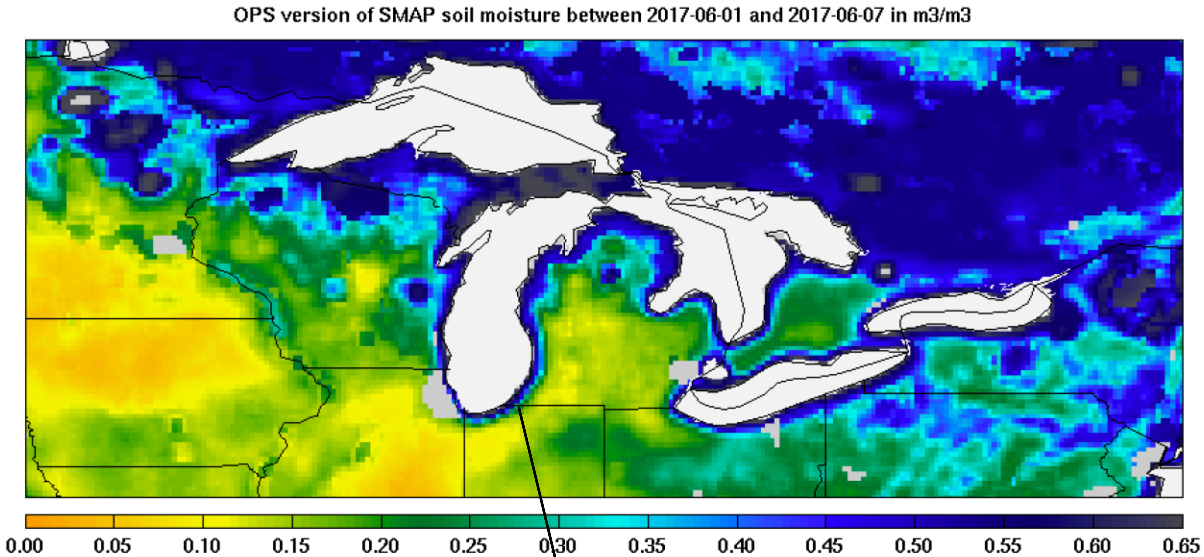
- Motivation
- Overview of the applied theory for L1B_TB product and L1B_TB_E
- Simulated data and sensitivity analysis
- Simulated examples and results
- Application to real data and results

Water contamination correction

- SMAP radiometer footprints over land can cover water from open water bodies or near coastlines
- Emissions by water integrated with emission by land, leads to underestimation of land TB
- Underestimated land TB leads to wet bias in soil moisture retrieval



Underestimated TB



Overestimated SM

Water contamination correction implementation

The total measured temperature can be separated into two contributions:

$$TB_p = (1-f) * TB_p^{land} + f * TB_p^{water} \qquad (p = v \text{ or } h)$$

– If footprint is on land we apply the formula:

$$TB_p^{land} = \frac{TB_p - f * \overline{TB}_p^{water}}{1-f}$$

- $\overline{TB}_p^{water}$ is an estimated TB at boresight computed from ocean SMAP observations free of contamination.

where *f* is the water fraction. *f*=1 in pure water and *f*=0 for pure land.

$$f = \int G.M d\Omega = \int_{\theta=[0,\pi],\psi=[0,2\pi]} G(\theta,\psi)\, M(\theta,\psi) \sin\theta \; d\theta d\psi \cong \int_{\theta=[0,10*\pi/180],\psi=[0,2\pi]} G(\theta,\psi) M \sin\theta \; d\theta d\psi$$

- M is the land mask defined over 1Km EASE2 grid.

L1B_TB_E implementation

– If grid point is on land we apply the formula:

$$TB_p^{land} = \frac{TB_p - f * \overline{TB}_p^{water}}{1-f}$$

– If grid point is on water we apply the formula:

$$TB_p^{water} = \frac{TB_p - (1-f) * \overline{TB}_p^{land}}{f}$$

where *f* is the water fraction. *f*=1 in pure water and *f*=0 for pure land.

$$f = \sum_{i=1}^{6} a_i f_i$$ where a_i are the Backus Gilbert coefficients.

Study based on simulations

- We first perform a simulation study to help us make decisions on how to apply the algorithm to real data.

- How well does our algorithm perform over simulated data?

- How to best estimate brightness temperature over water or ocean - computed from ancillary data or SMAP observations?

- How big should the averaging area be?

- What is the sensitivity of our algorithm to levels of water contamination in the applied estimated brightness temperature?

Simulation

$$TB = \int G.\,tb d\Omega = \int_{\theta=[0,\pi],\psi=[0,2\pi]} G(\theta,\psi)\, tb(\theta,\psi)\sin\theta \;\, d\theta d\psi$$

$$\cong \int_{\theta=[0,10*\pi/180],\psi=[0,2\pi]} G(\theta,\psi) tb(\theta,\psi)\sin\theta \;\, d\theta d\psi$$

- Dielectric constant (ε) over ocean is generated by using Klein and Swift model.
- Dielectric constant (ε) over land is generated by using Mironov model.

- $R_{vv} = \frac{\varepsilon \;\cos\theta - \sqrt{\varepsilon - \sin\theta^2}}{\varepsilon \;\cos\theta + \sqrt{\varepsilon - \sin\theta^2}}$ $\qquad R_{hh} = \frac{\cos\theta - \sqrt{\varepsilon - \sin\theta^2}}{\cos\theta + \sqrt{\varepsilon - \sin\theta^2}}$

$$tb = (1 - |R|^2)Ts$$

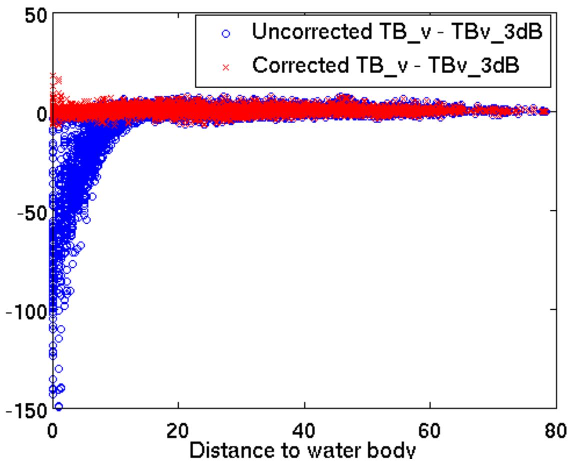
- TB over land is computed using plane surface model.
- TB over ocean is computed using model that takes into account wind.

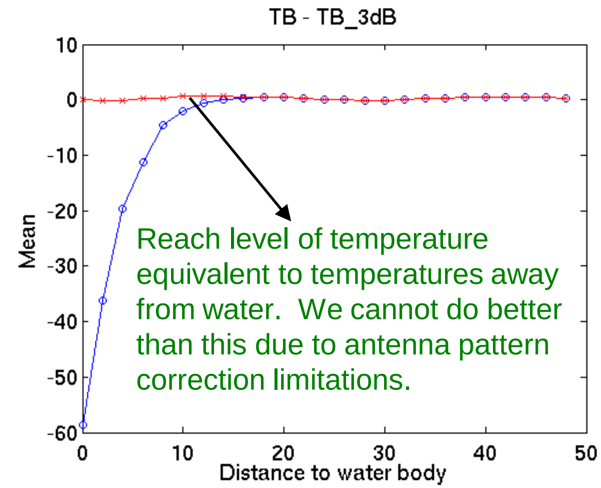
- For comparison we also compute the TB_3dB integrating the *tb* within the 3dB beam and only over land (*M* land mask)

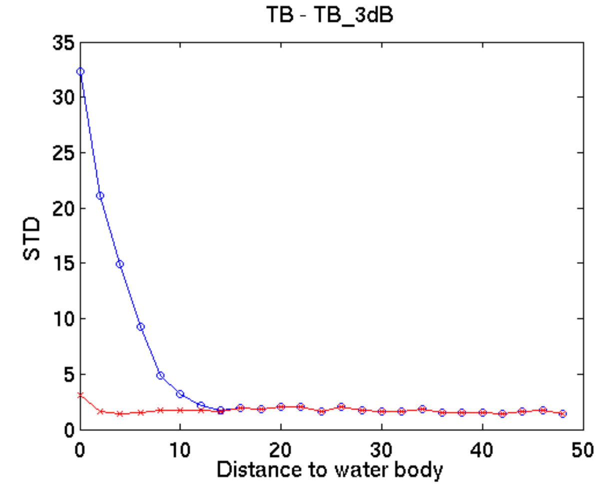
$$TB\_3dB = \int_{3dB} G\; M\; tb d\Omega$$

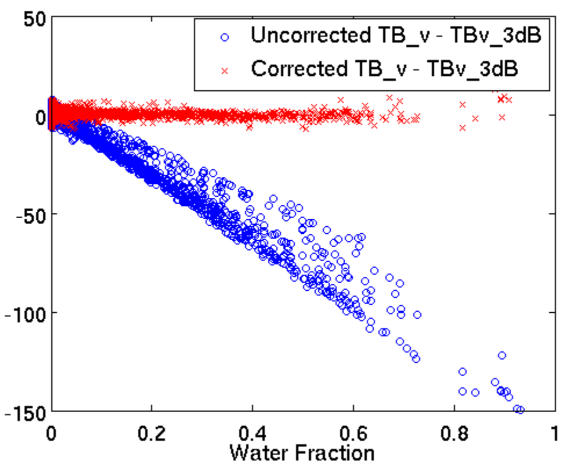
Statistics based on simulation

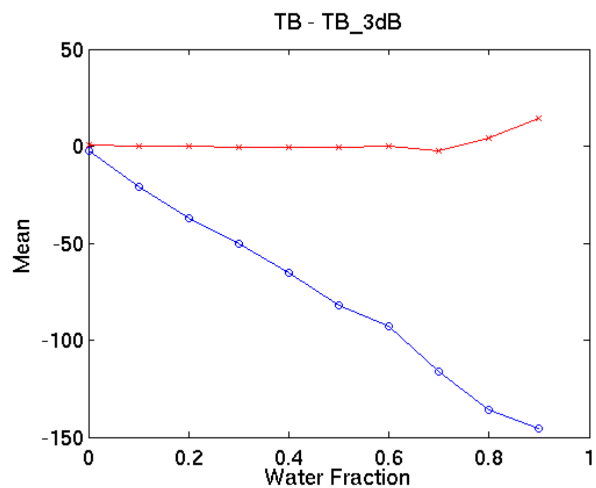
- We compare the brightness temperature against the TB_3dB
- Differences are reduced after corrections.
- Mean values close to water reach same levels as differences away from water

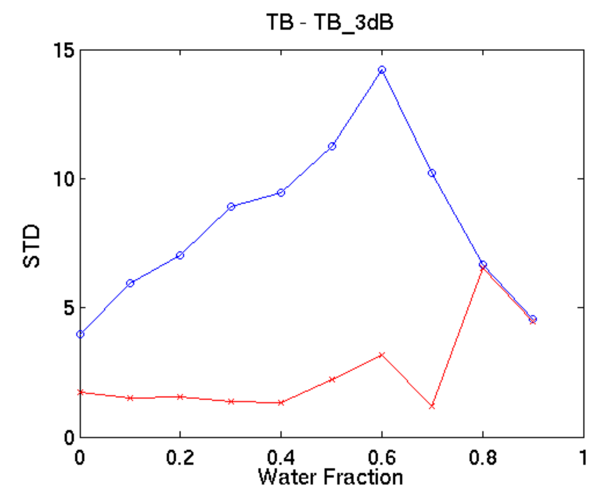




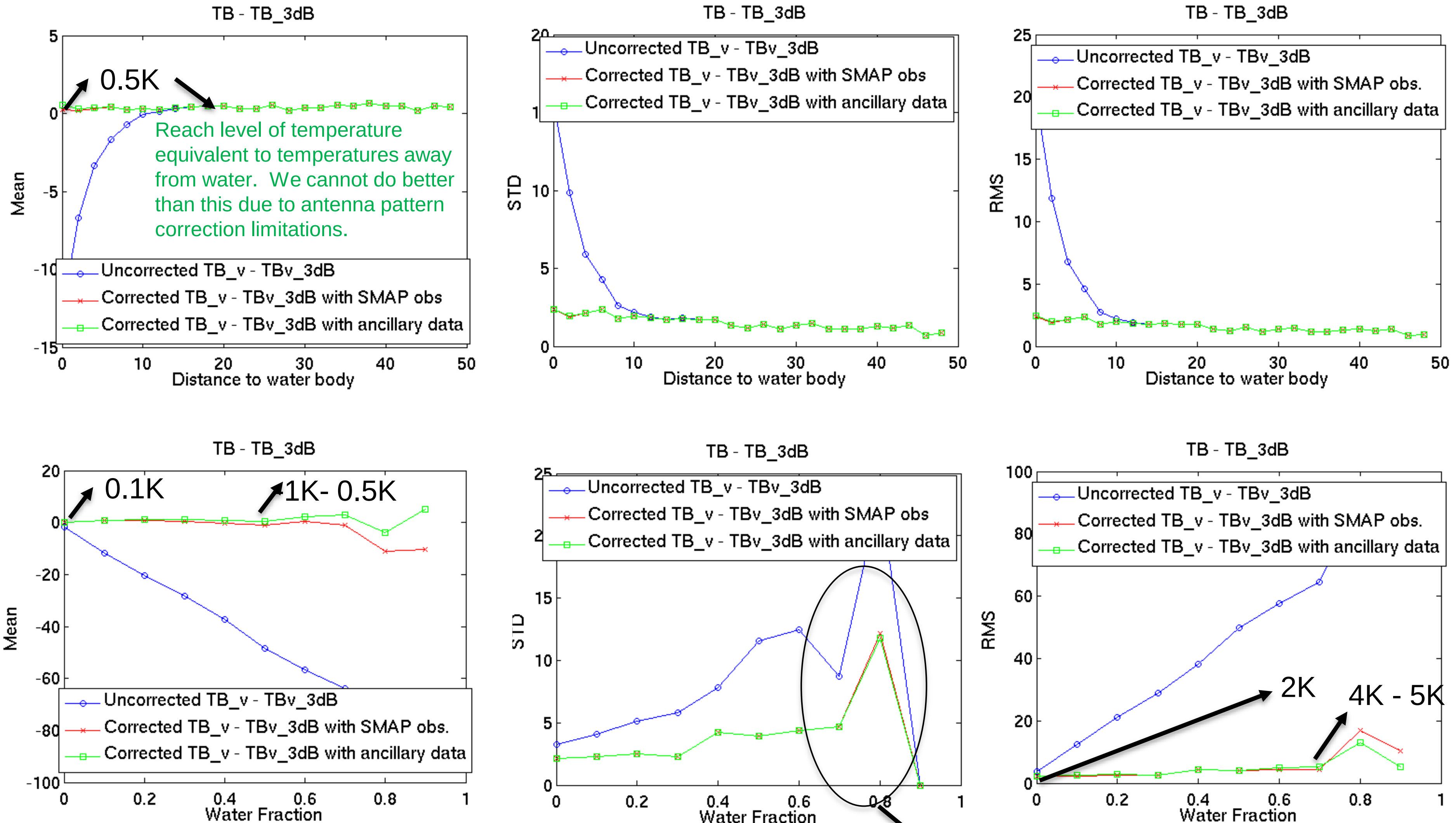








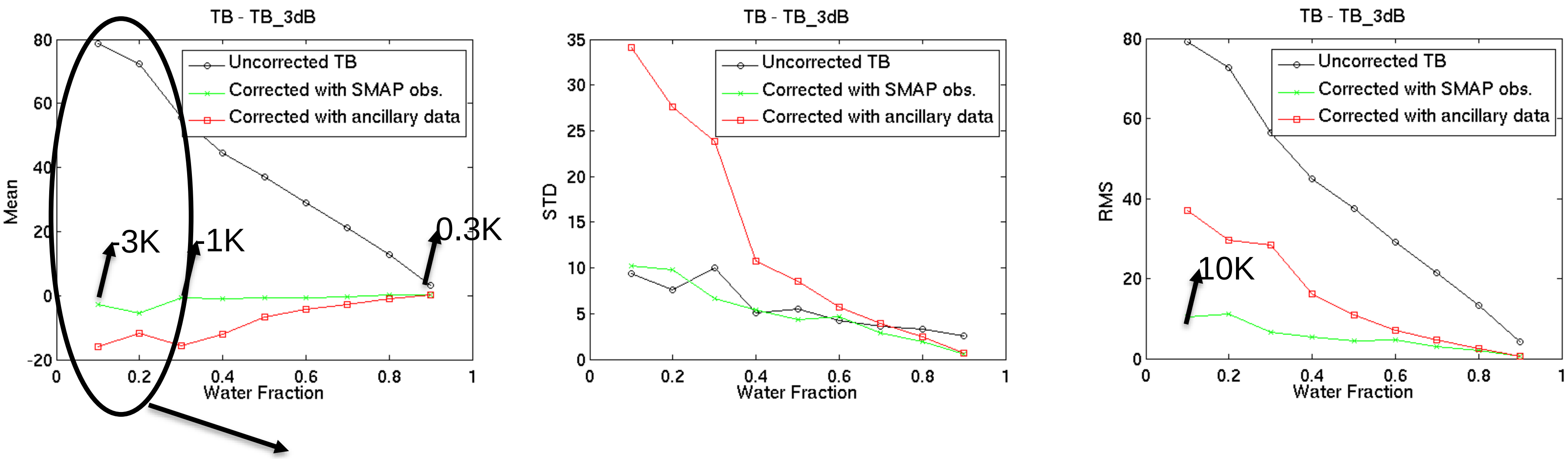
Statistics based on simulations – Great Lakes SMAP observation vs ancillary data



This area corresponds to small islands. No enough data for stats

Statistics based on simulations – Great Lakes SMAP observation vs ancillary data

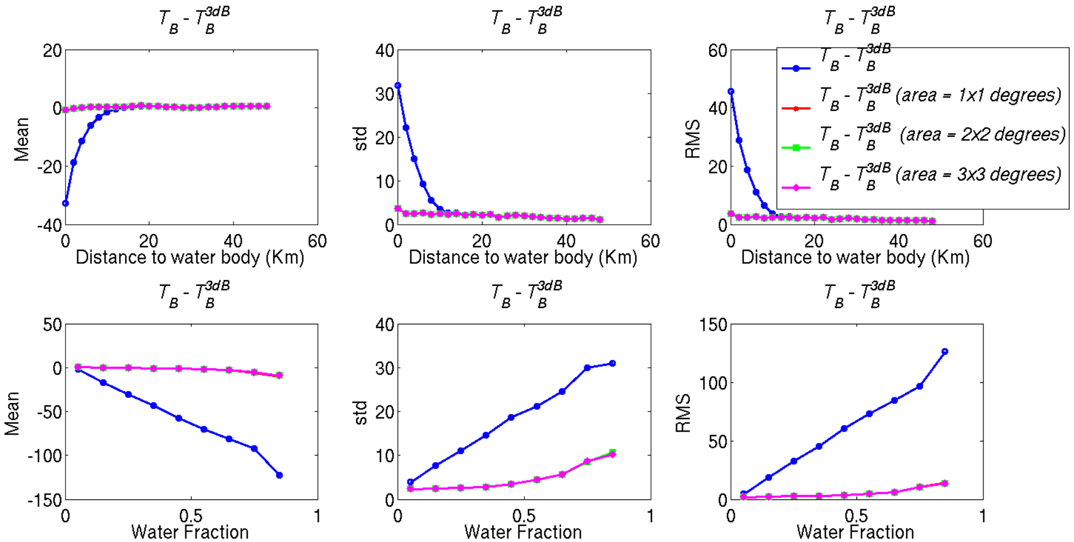
The use of SMAP observations shows much better performance over water



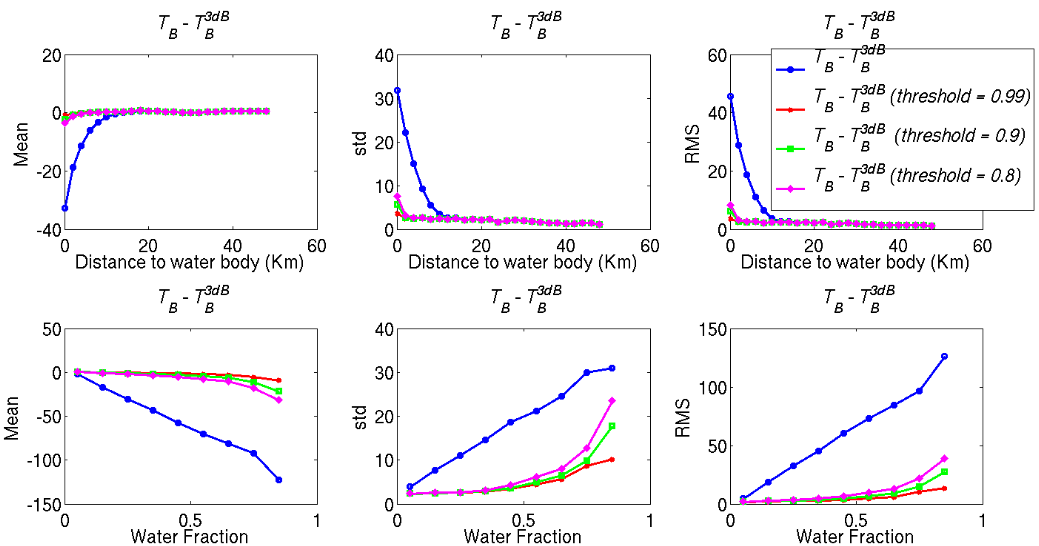
This area corresponds to small lakes. No enough data for stats

0=Land 1=Water

Sensitivity analysis

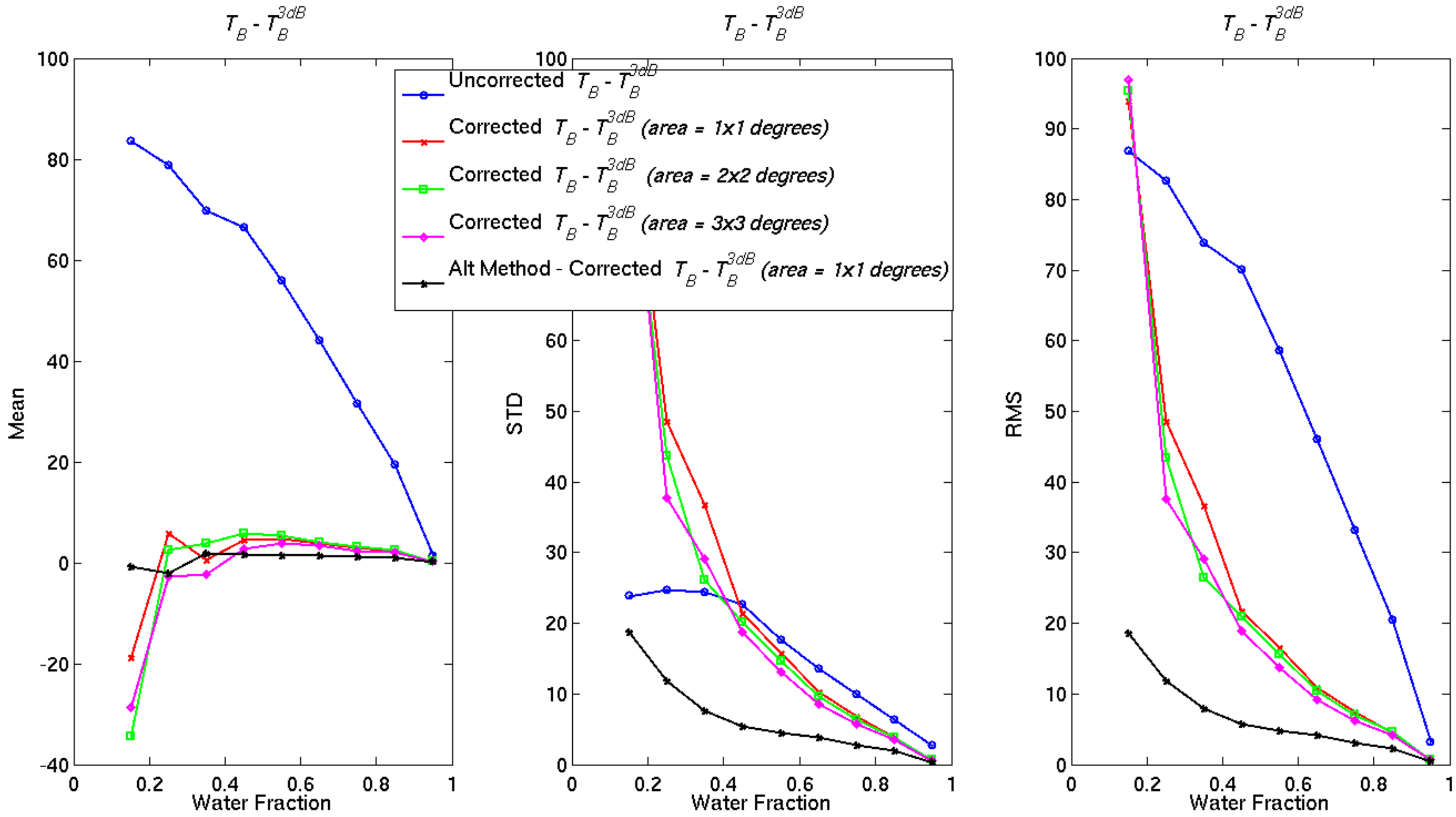


Mean, std, and RMSE resulting from the water contamination correction. We display the difference of uncorrected T_B - $T_{B_{land}}^{3dB}$ (blue line) and corrected T_B -$T_{B_{land}}^{3dB}$ for several searching areas (1x1 degrees, 2x2 degrees and 3x3 degrees). Top row displays statistics as a function of distance to water bodies. Bottom row displays statistics as a function of water fraction.



Mean, std, and RMSE resulting from the water contamination correction. We display the difference of uncorrected T_B - $T_{B_{land}}^{3dB}$ (blue line) and corrected T_B -$T_{B_{land}}^{3dB}$ for several thresholds (0.99, 0.9, 0.8). Top row displays statistics as a function of distance to water bodies. Bottom row displays statistics as a function of water fraction.

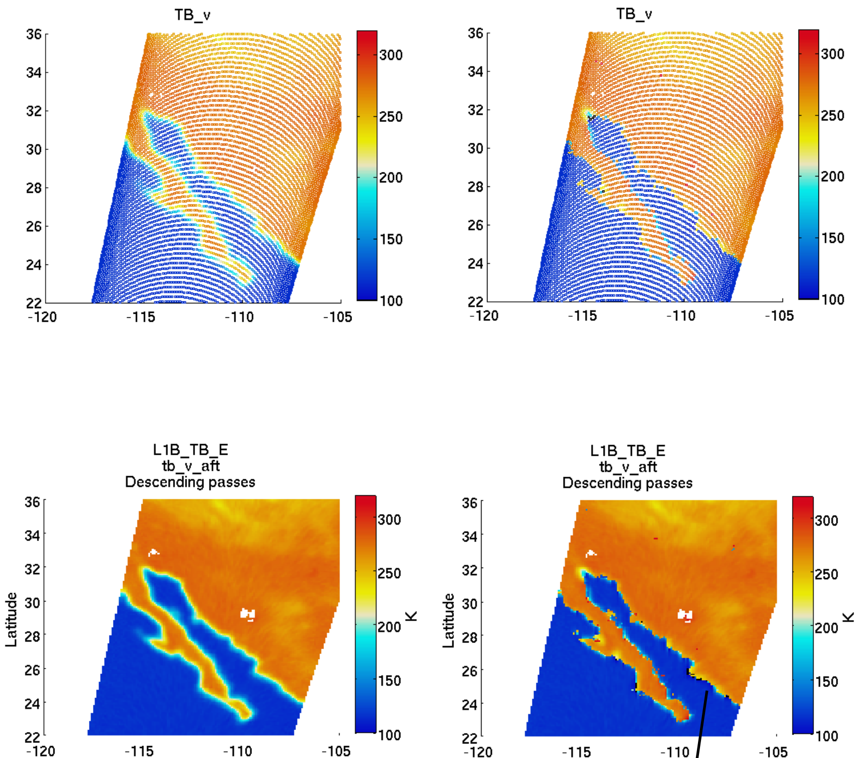
Estimated land brightness temperature to retrieve water TB



- Figure shows better performance when we use what we call alternative approach.
- Alternative approach uses already corrected land brightness temperature to estimate land temperature used to retrieve water TB.s

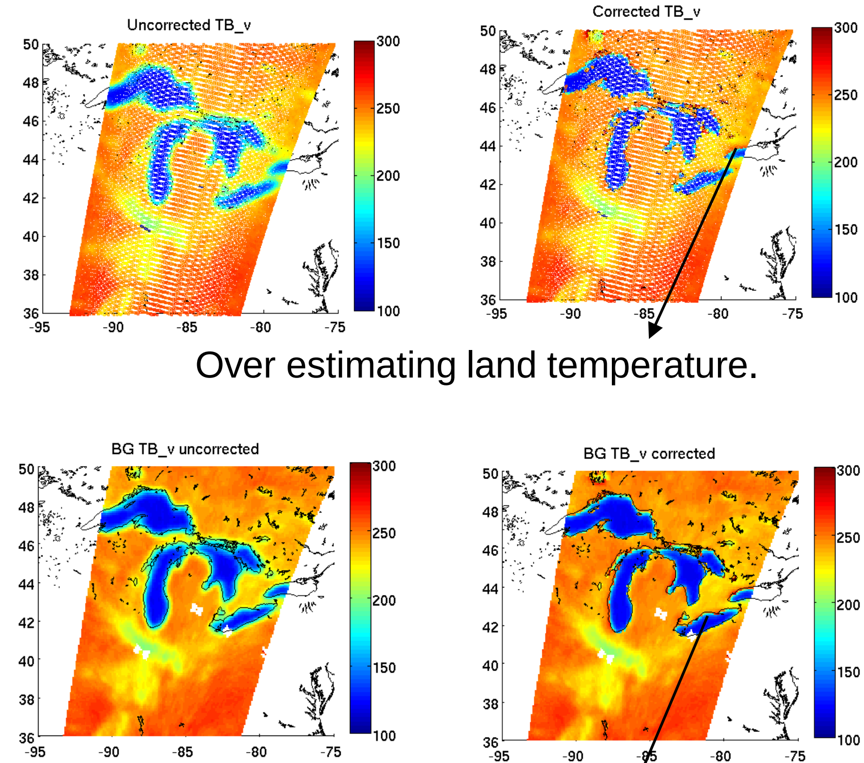
Results from Product

Baja California



Underestimating ocean TB.

Great Lakes



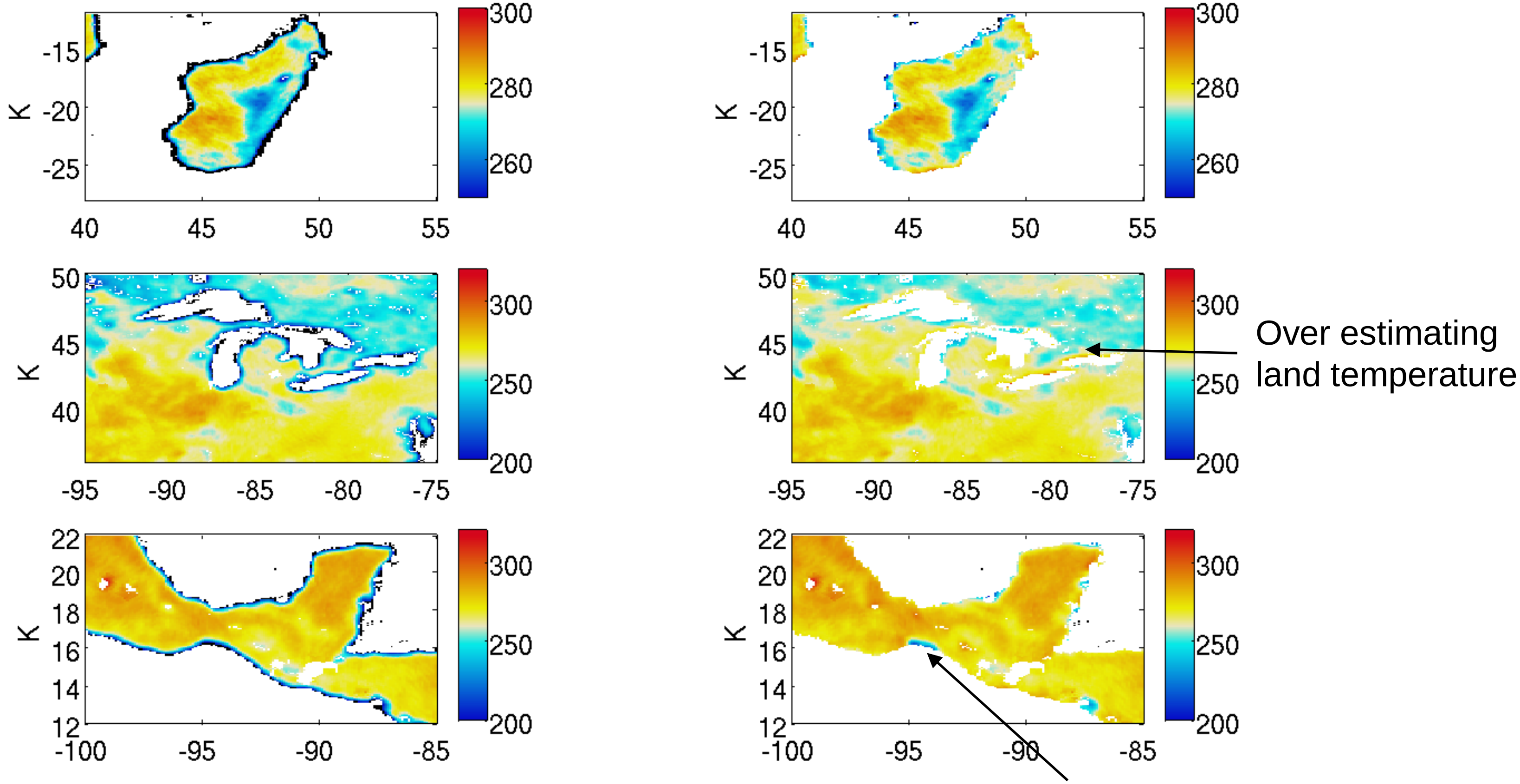
Over estimating land temperature.

Over estimating water temperature.

- Sharper coastlines
- Detection of small islands
- Some anomalies: under or over estimation of brightness temperatures

Results over land from real data

06/[04-06]/2018



- Sharper coastlines
- Detection of small islands
- Some anomalies: under or over estimation of brightness temperatures

Results over water from real data

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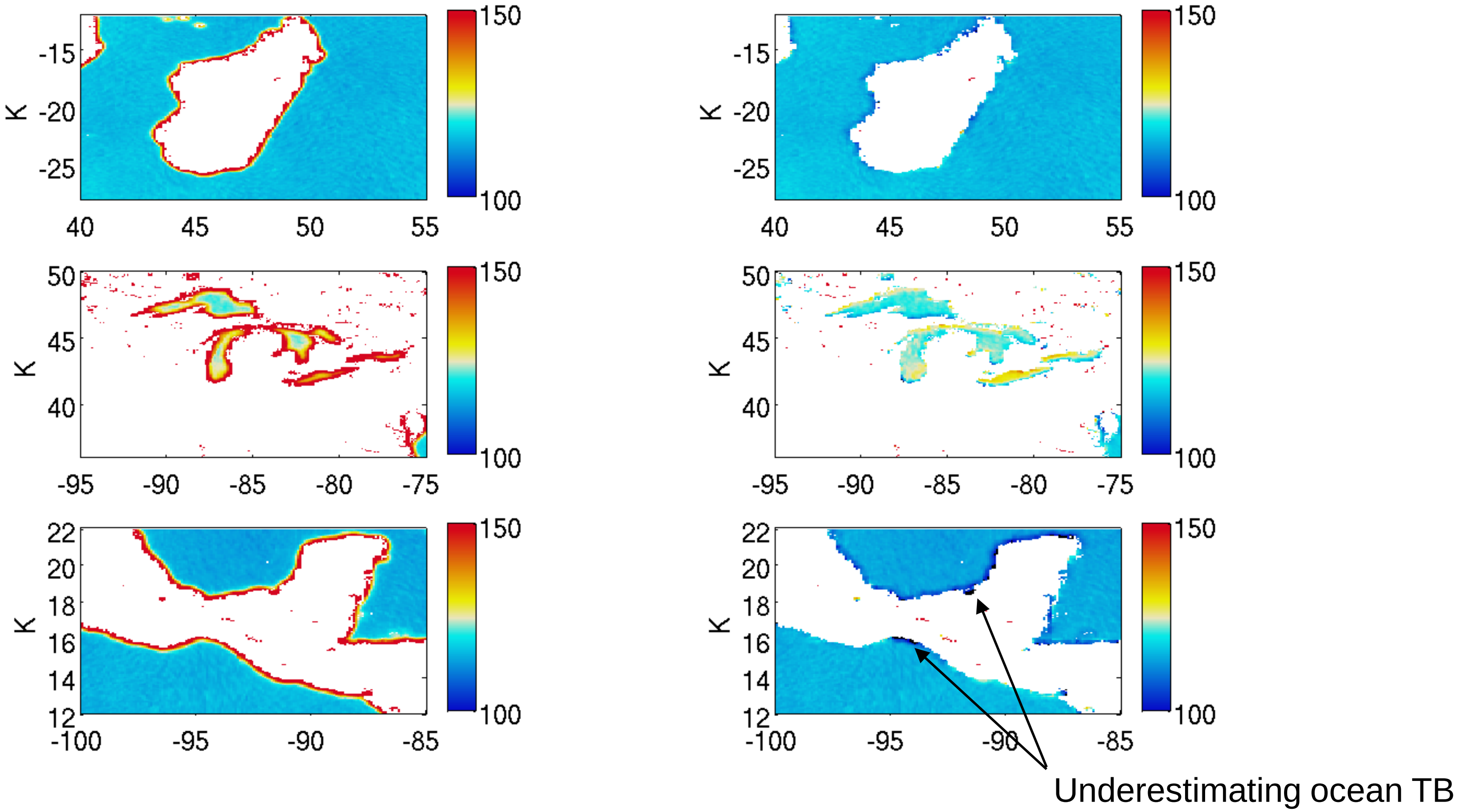
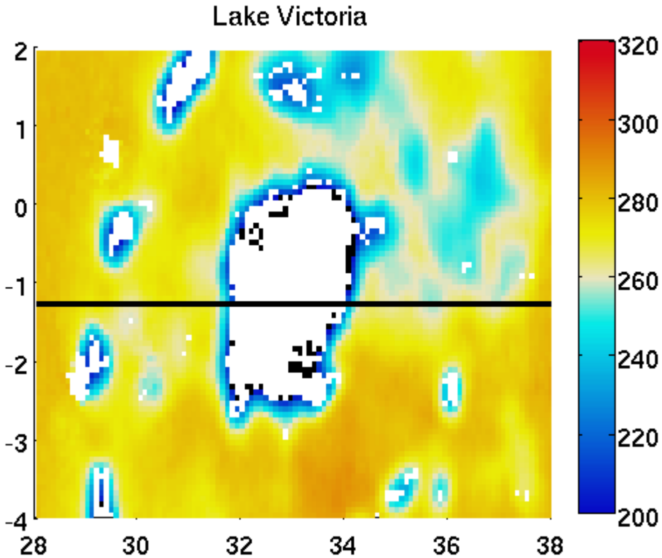
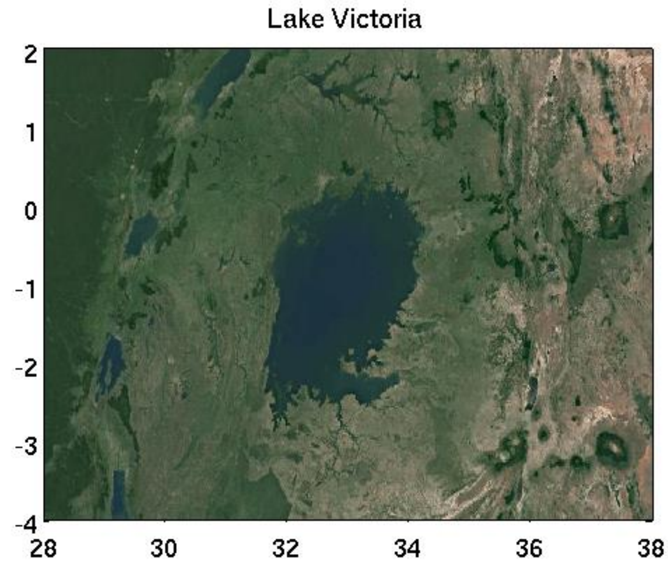
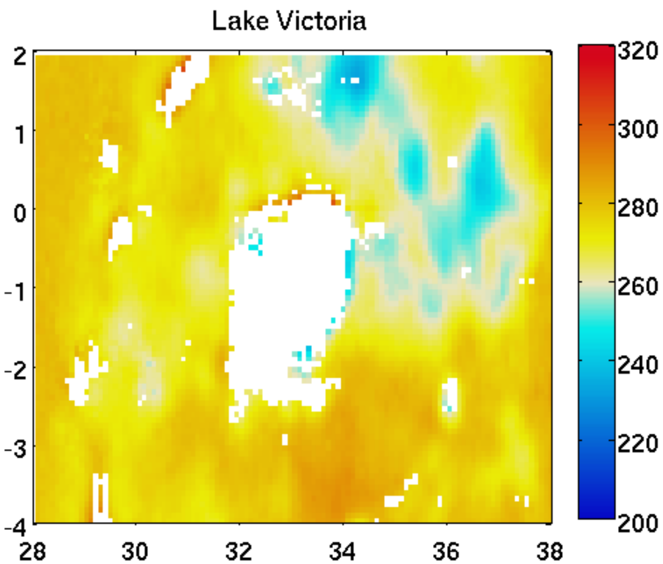


- Sharper coastlines
- Detection of small islands
- Some anomalies: over estimation of brightness temperatures

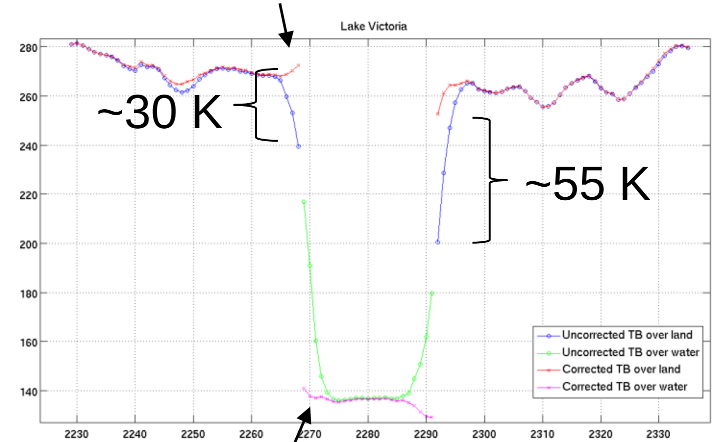
Lake Victoria







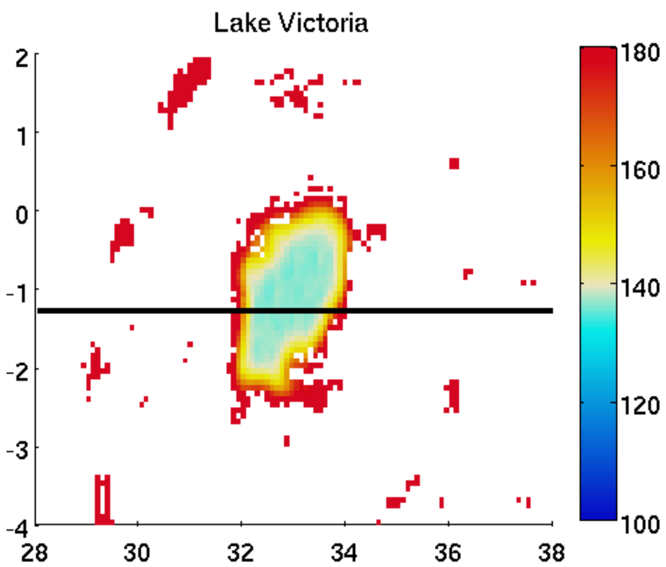
Over estimating land temperature.

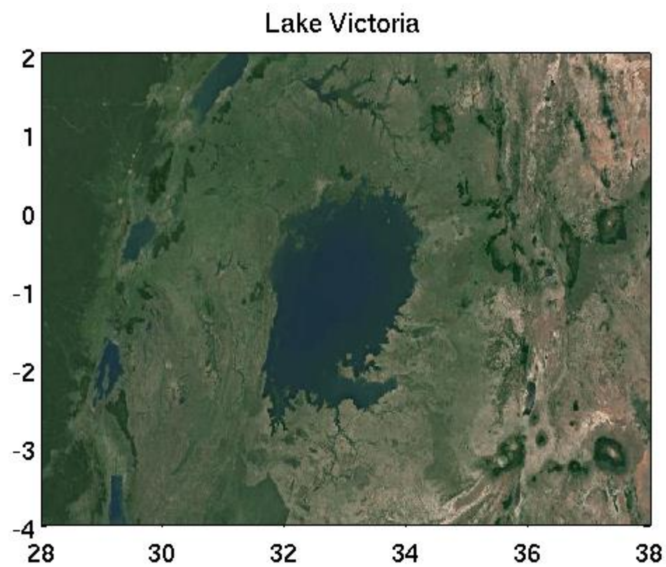


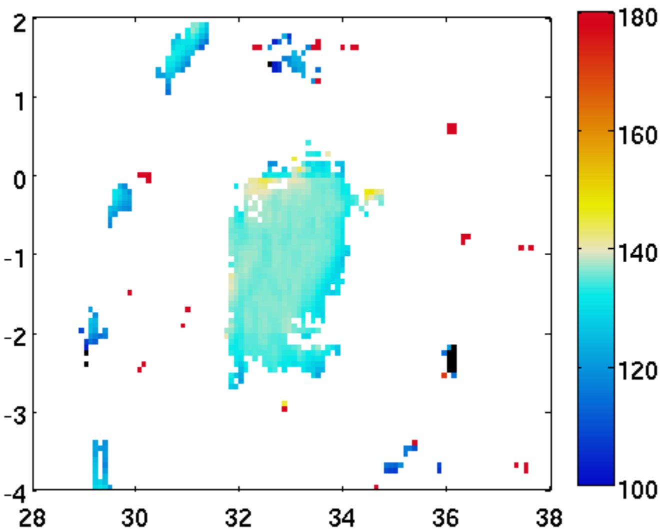
Over estimating water temperature.

Caused by Geolocation Errors?

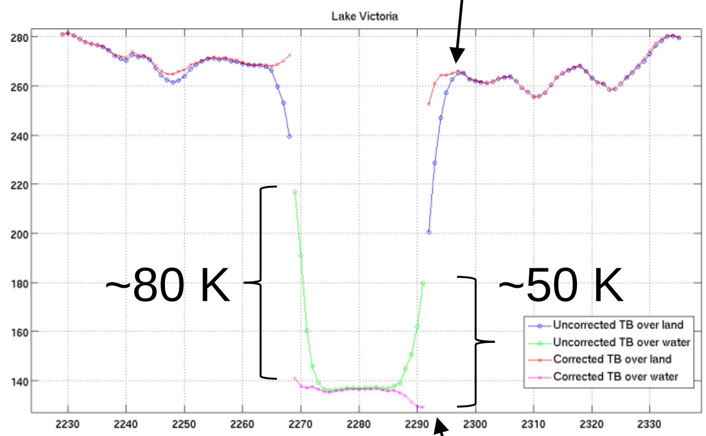
Lake Victoria







Underestimating land TB.

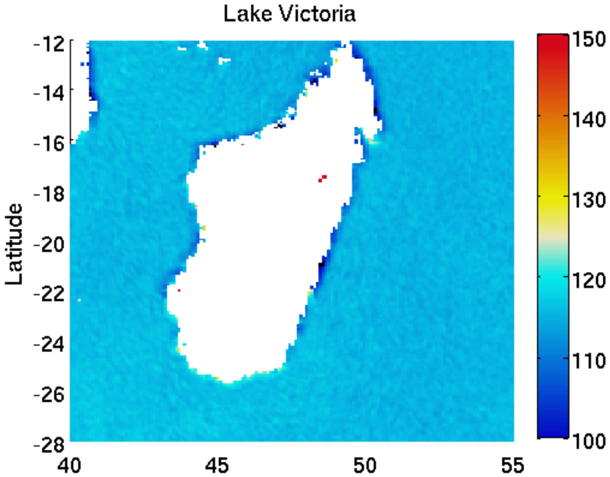


Underestimating water TB.

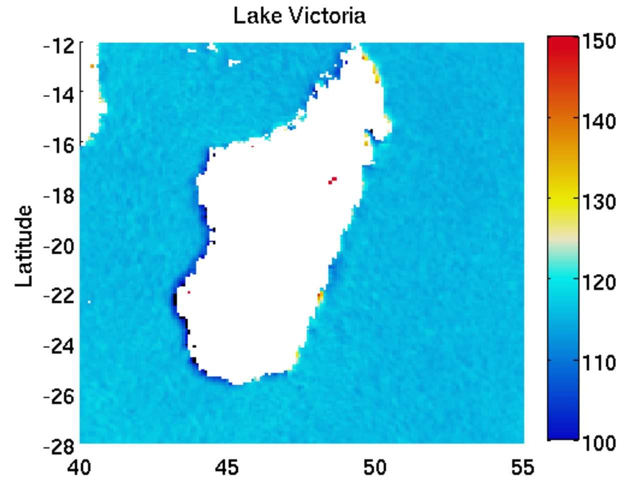
Caused by Geolocation Errors?

Possible geolocation errors

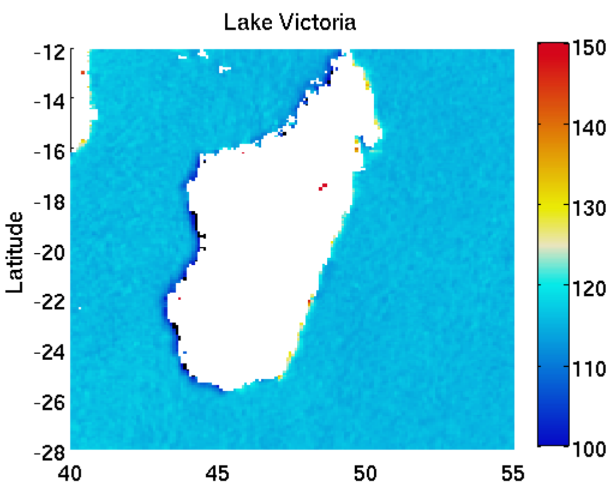
Ascending aft pass



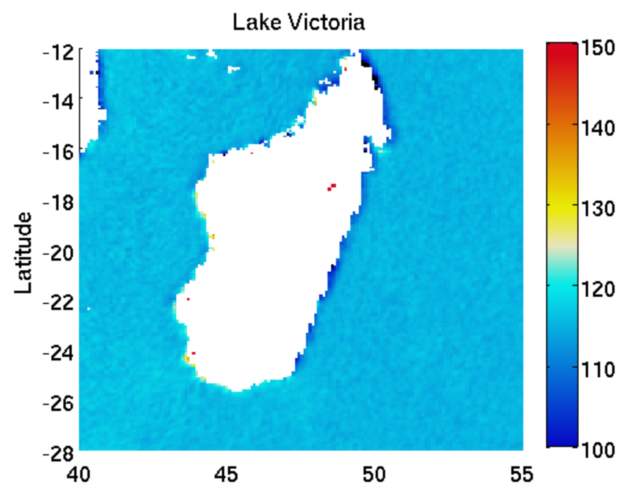
Ascending fore pass



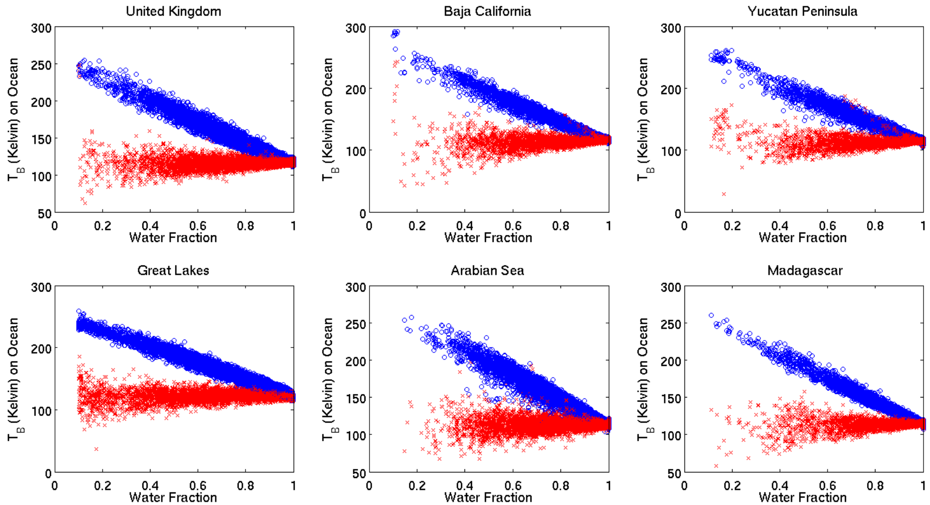
Descending aft pass



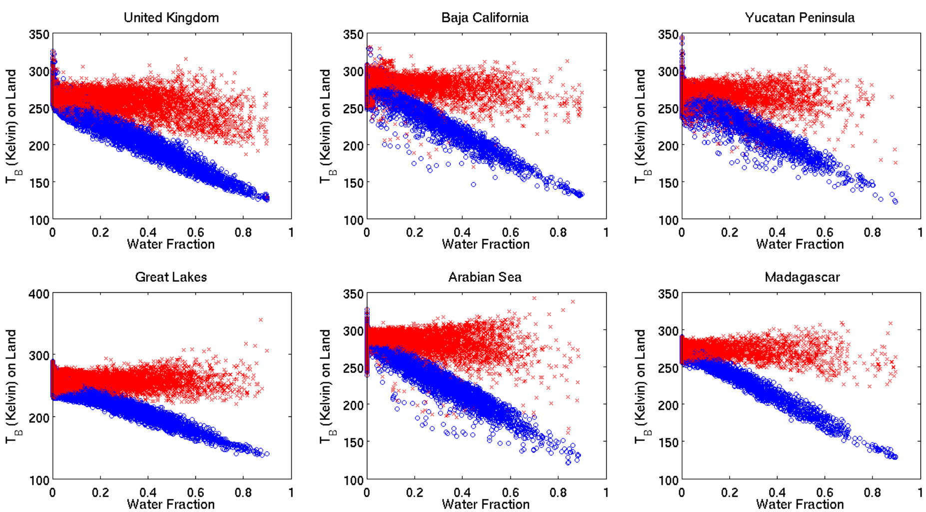
Descending fore pass



Bias removal – Results based on real data



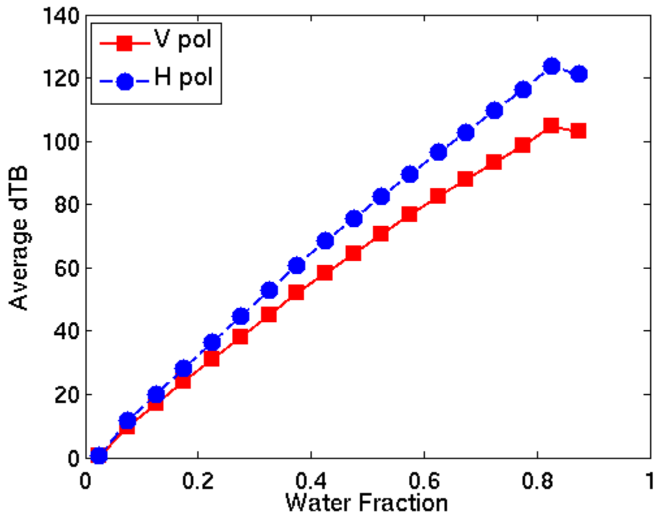
Scattering plot of uncorrected T_B (blue circles) and corrected land T_B (red times) as a function of Water fraction. From left to right; Top: United Kingdom, Baja California and Yucatan Peninsula; Right: Great Lakes, Arabian Sea and Madagascar. Before correction the T_B decrease with land fraction and after correction, we remove that dependence.

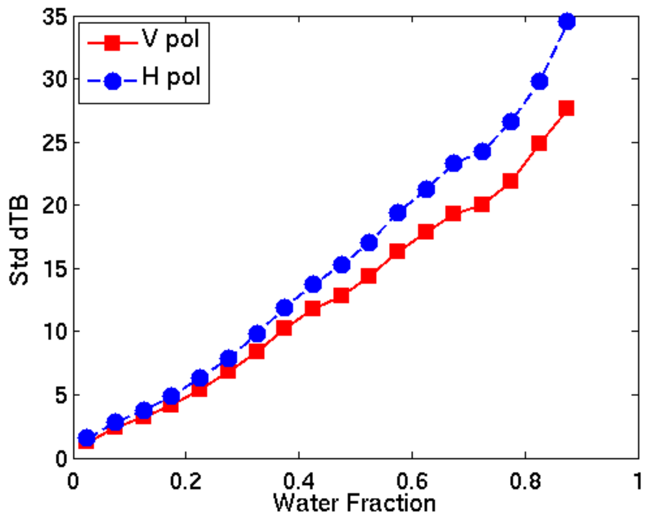


Scattering plot of uncorrected T_B (blue circles) and corrected water T_B (red times) as a function of Water fraction. From left to right; Top: United Kingdom, Baja California and Yucatan Peninsula; Right: Great Lakes, Arabian Sea and Madagascar. Before correction the T_B decrease with land fraction and after correction, we remove that dependence.

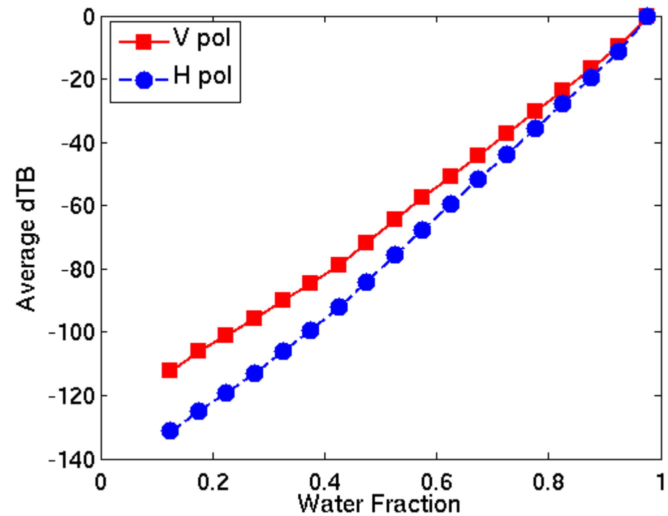
Expected correction values as a function of water fraction and the expected uncertainty

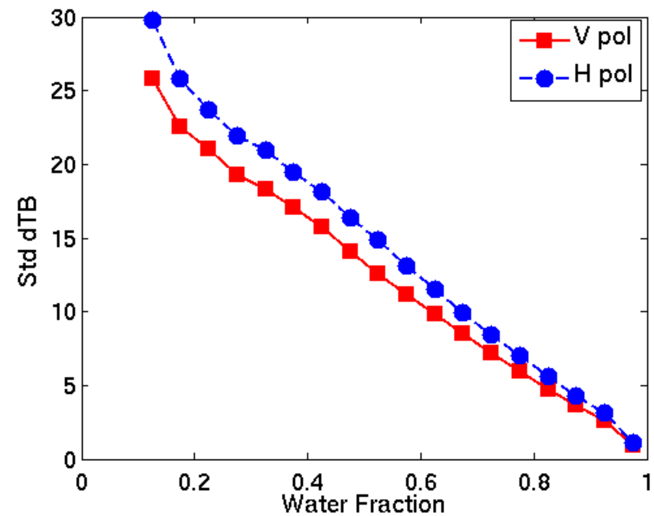
Land TB correction uncertainty





Water TB correction uncertainty





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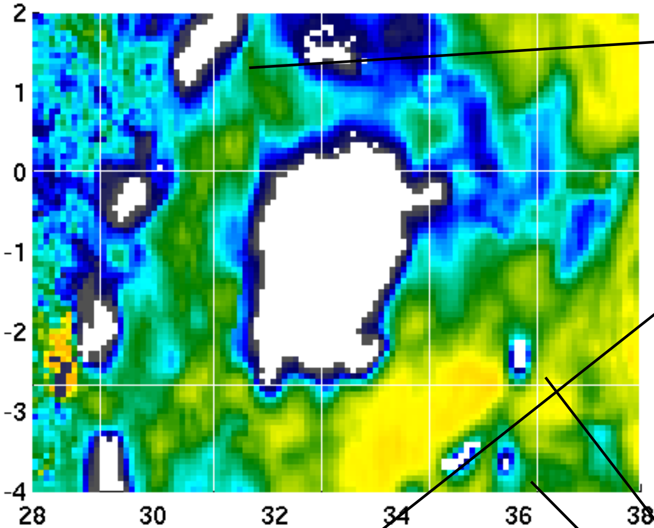
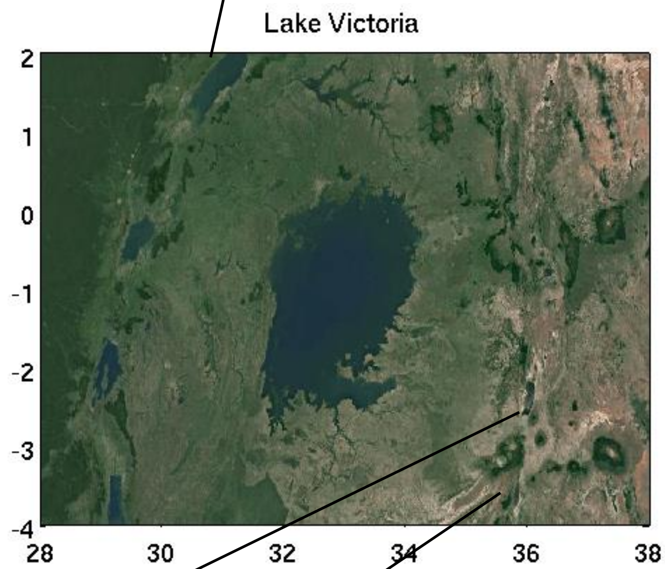
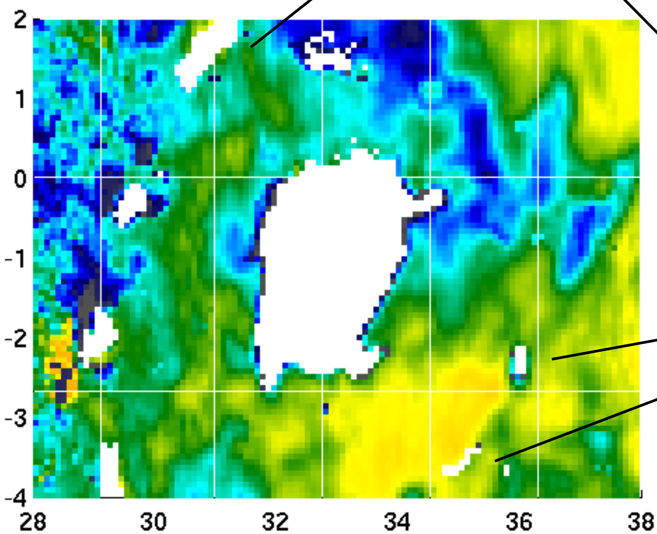


Blue rings around lakes eliminated or reduced





Blue rings around lakes eliminated

Future Work

- Perform correction on icy areas. The current implementation does not perform correction in areas with an ice fraction other than zero

- Incorporate dynamic land mask and ice mask

- Improve correction considering water bodies seasonal changes.